

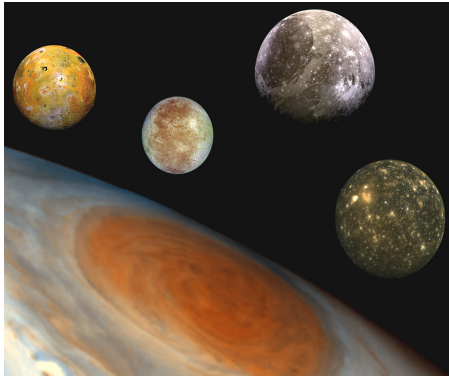
# Future directions and needs for high pressure/high energy geoscience research at NSLS-II

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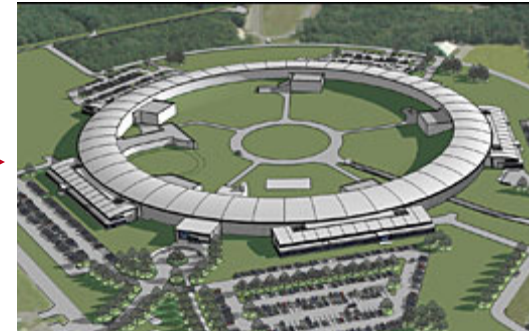
# Earth's Interior Structure



**Geophysical observations**



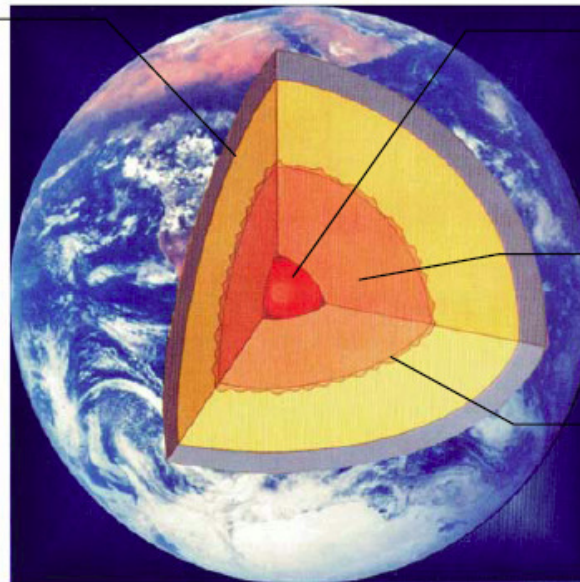
**High p-T experiments**



**Mineral Properties**

**Interpretations  $\Rightarrow$  Model**

Mantle dynamics?  
Discontinuity?  
Phase transitions?  
Element partitioning?  
Melting?  
Oxidation?  
Hydration?  
High-low spin?  
Temperature?  
Composition?



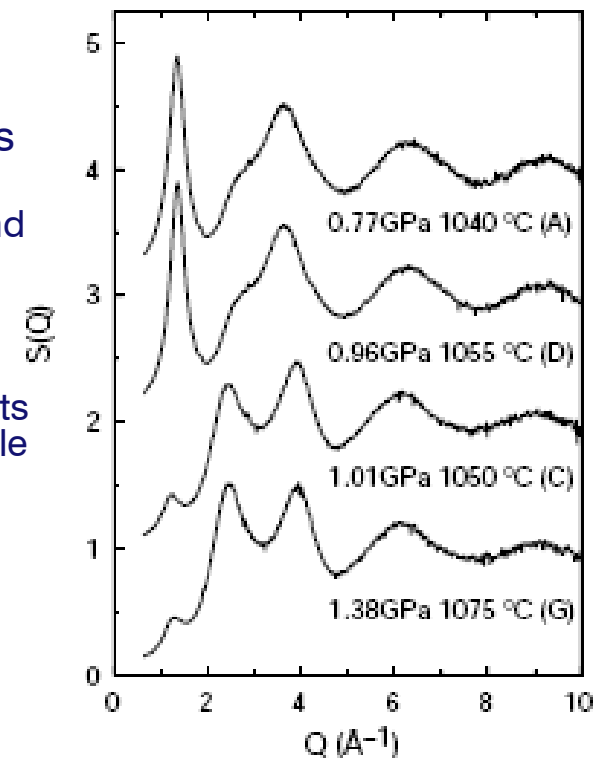
Inner core anisotropy?  
Super-rotation?  
Magnetism?

Core dynamo?  
Composition?  
Temperature?

CMB reactions?  
Partitioning?  
Anisotropy?  
Melting?

# Melts

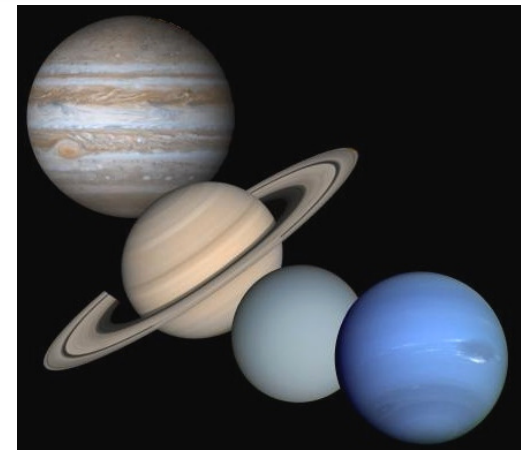
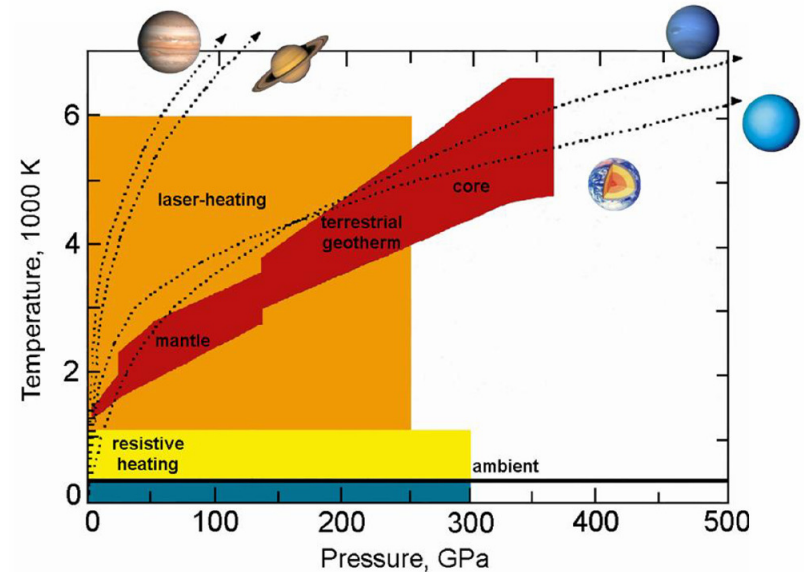
- The dynamic processes in earth interior involving magmatic liquids (4-6 % of mantle is molten)
- Principal mechanisms for mass and energy (heat) transfer
- Little is known about structure and properties of melts at pressures and temperatures of Earth's interior
  - In situ experiments on silicate melts are currently beyond state of the art
- Building models for mantle dynamics
  - Extrapolation of structure and properties of glasses/melts to pressure and temperature conditions of Earth's mantle
    - Ignoring that glass structure is a snapshot at  $T_g$
    - Neglect probable polyamorphic phase transitions
- Experiments can be state of the art at NSLS-II



Structure factor of liquid phosphorus  
Katayama *et al.*, 2006

# Earth's core and beyond

- Conditions at Earth's core:
  - 330 to 360 GPa
  - 5,000 to 6,000 °C
- Dimensions
  - Sample < 30  $\mu\text{m}$   $\times$  5  $\mu\text{m}$
  - Laser heating  $\sim$  20  $\mu\text{m}$   $\times$  20  $\mu\text{m}$
  - X-ray  $\sim$  10  $\mu\text{m}$   $\times$  10  $\mu\text{m}$
- Structure and properties of iron and iron alloys at core pressure and temperature
  - Understand core anisotropy, super rotation and magnetism
- Structure and properties of H<sub>2</sub>, NH<sub>3</sub> and He
  - Interior structure of gas giants



# Experiments

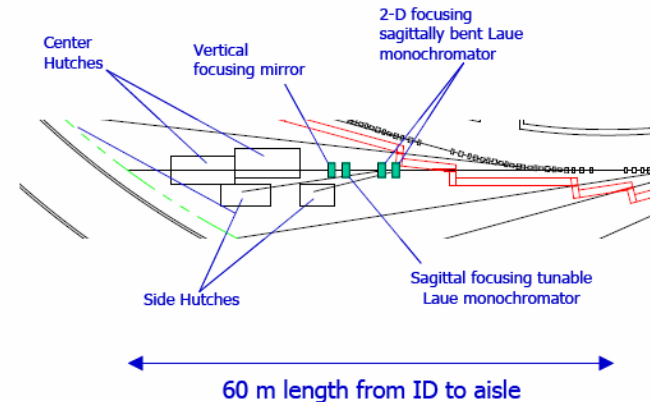
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New sciences appears across the board at each  $P$  interval!

- Crystalline Materials
  - Strain resolution of  $10^{-6}$  (reduce gap between lab and geological flow)
- Disordered and non-crystalline materials
  - Nano-crystalline Materials
  - Liquids and Melts
  - Partially crystalline Materials and Mineral Inclusions
    - Elasticity, Density, Structure
- Reactions
  - In situ investigations
  - Time resolved studies
- Single-crystal diffraction
  - In polycrystalline matrix

# Proposed Beamlines

- High Pressure Diffraction
  - Super conducting Wiggler
  - 4 End-Stations
    - 2 Fixed Energy Stations
      - DAC:  $E \sim 35\text{-}40\text{ keV}$ ,  $< 1\text{ }\mu\text{m}$ 
        - Laser heating (Yt: fiber laser,  $\text{CO}_2$ ), low temperature capabilities, Imaging capabilities
      - LVP:  $E \sim 35\text{-}40\text{ keV}$ 
        - 500 t Press with interchangeable modules
    - 2 Variable Energy Station
      - DAC:  $E \sim 20\text{-}100\text{ keV}$ ,  $< 5\text{ }\mu\text{m}$ 
        - Laser heating (Yt: fiber laser,  $\text{CO}_2$ ), low temperature capabilities, Imaging capabilities
      - LVP: monochromatic & white beam capabilities
        - 2000 t Press with interchangeable modules



# Proposed Beamlines

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- Infrared Spectroscopy beamline
  - Bending magnet
    - Mid and far infrared
    - Unique & world class program at NSLS → NSLS-II
- Inelastic Scattering and Spectroscopy beamline
  - Undulator (U19)  $E \sim 5\text{-}25$  keV,  $\sim 1$  eV resolution
  - Taking full advantage of unique source characteristics of NSLS-II
  - XAS, XES, IXS, RIXS, NRIXS, NFS

# Support Laboratory

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High Pressure will be an important sample environment also on beamlines not dedicated to high pressure

- Gas loading
- Preparation Area
  - Microscopes
  - Mechanical, spark erosion and laser micro-drill system
  - Staging
  - Inert atmosphere loading / glove box
  - Fume hood, Furnaces
- Off line Raman system
- Off line laser heating system
- Micro-engineering capabilities for sample and gasket preparation
- Machine / Electronic Shop

Analytical capabilities → Center for Functional Nanomaterials, other BNL Institutes

- Focused Ion Beam analysis (FIB)
- SEM/TEM
- Microprobe

# Organization

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- High pressure working group
  - Interface to beamlines which plan to have high pressure as a sample environment
- Beamline Advisory Teams
  - Ongoing discussion about team members